



THE EFFECTS OF PILATES MAT AND PILATES REFORMER TRAINING ON CORE STRENGTH IN AN AEROBIC GYMNASTICS COMMUNITY

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ABSTRACT

The background of this study is the importance of core strength in supporting body stability and movement control. Members of an aerobic gymnastics community who regularly engage in physical activity do not necessarily possess optimal core muscle strength, as aerobic exercise does not specifically focus on strengthening the core muscles. Pilates Mat and Pilates Reformer are training methods that can be used to strengthen the core muscles, but they have different training characteristics. This study addresses the effects of Pilates Mat and Pilates Reformer training on core strength, the differences between the effects of these two methods, and which method produces greater improvements among members of an aerobic gymnastics community in Magelang. The purpose of this study was to determine the effects and differences between the two training methods and to compare their improvements in core strength. This study employed a quantitative approach with a quasi-experimental design using a Two-Group Pretest–Posttest Design. The sample consisted of 20 members of the Maple Magelang aerobic gymnastics community, with 10 participants in each group assigned through ordinal pairing. The intervention was conducted over 14 sessions. Data were measured using a Back and Leg Dynamometer and analyzed using Mixed Analysis of Variance (Mixed ANOVA). The results showed that the mean core strength of the Pilates Mat group increased from 46.00 to 88.05, representing a mean change of 42.05. In the Pilates Reformer group, the mean increased from 44.85 to 67.15, representing a change of 22.30. The Mixed ANOVA results indicated a significant change over measurement time ($F = 85.091$; $p < 0.001$) and a significant interaction between measurement time and training group ($F = 8.015$; $p = 0.011$). These findings indicate that changes in core strength differed significantly between the two groups. The analysis of the group effect also revealed a statistically significant result ($F = 4.667$; $p = 0.044$).

Keywords: aerobic gymnastics; core strength; pilates mat; pilates reformer

How to cite (in APA style)

Damara, D. A., & Setiawan, I. (2026). The Effects of Pilates Mat and Pilates Reformer Training on Core Strength in An Aerobic Gymnastics Community. *Indonesian Journal of Global Health Research*, 8(6), 1239–1248. <https://doi.org/10.37287/ijghr.v8i6.2870>.

INTRODUCTION

Physical activity is an important factor in maintaining health, improving physical fitness, and supporting quality of life. The World Health Organization recommends that adults engage in 150–300 minutes of moderate-intensity aerobic activity per week or 75–150 minutes of vigorous-intensity activity per week, accompanied by regular muscle-strengthening activities to achieve optimal health benefits (Bull et al., 2020). However, meeting physical activity recommendations is not solely a matter of exercise duration and frequency; it also depends on the types of activities performed and the components of physical fitness being developed. Strain et al. (2024) highlighted the limited global monitoring of muscle-strengthening activities, despite their importance as a component of physical activity recommendations. In line with this, Brellenthin et al. (2023) explained that muscle-strengthening exercises provide additional benefits for muscular strength and musculoskeletal fitness that cannot be fully achieved through aerobic activity alone. Therefore, combining aerobic exercise with muscle-strengthening activities is an important approach to developing overall physical fitness.

One component of physical fitness that deserves particular attention is core strength. Core strength refers to the ability of the core muscles to generate force to support body stability and the execution of various movements. This ability is associated with other functions of the core muscles, including

core endurance and core power, which work together according to the demands of physical activity (Schulte et al., 2025). Schulte et al. (2024) also emphasized that core strength is a multidimensional capacity; therefore, its assessment should consider the relevant functional characteristics of the core muscles. During movement, the core muscles comprise groups of muscles surrounding the abdomen, lower back, pelvis, and spine that work synergistically to maintain posture and control body movements. Consequently, core strength is an important component in supporting balance, coordination, postural stability, and movement efficiency.

Functionally, the core muscles serve as a central stabilizing system that connects upper- and lower-extremity movements through the kinetic chain mechanism. Optimal core muscle function supports force transfer between body segments, enabling movements to be performed with greater control and efficiency (Ko et al., 2024; Schulte et al., 2025). Conversely, inadequate core muscle function may affect postural control and body stability. This issue is relevant to maintaining musculoskeletal health, considering that low back pain remains one of the leading causes of disability worldwide (GBD 2021 Low Back Pain, 2023). In exercise settings, developing core strength requires appropriate training stimuli that align with the objectives, individual characteristics, and training dosage. Rodríguez-Perea et al. (2023) identified physical activity, exercise type, frequency, duration, and individual characteristics as factors associated with core muscle function. Meanwhile, Kumar and Zemkov (2022) emphasized the importance of specific and structured training in developing physical abilities. Therefore, regular physical activity should be complemented by appropriate training methods to optimize specific components of physical fitness.

One form of physical activity widely practiced by the public is aerobic gymnastics. This activity combines rhythmic and coordinated body movements with musical accompaniment, making it suitable for community fitness programs (Setiawan, 2010; Latuheru et al., 2022). Aerobic gymnastics has the potential to improve cardiorespiratory fitness and promote an active lifestyle (Latuheru & Arfanda, 2023). Arfanda et al. (2025) also explained that aerobic dance may provide benefits for cardiorespiratory capacity, maximal oxygen uptake, body composition, and psychological aspects. Furthermore, a systematic review by Lu et al. (2024) indicated that structured dance activities may benefit physical function, balance, and postural control, although their application should account for the characteristics of the activity and the population being studied. Despite these benefits, the characteristics of aerobic exercise do not necessarily provide the same strengthening stimulus to every muscle group. Therefore, individuals who regularly participate in aerobic gymnastics still require assessments of specific fitness components, including core strength, which cannot be inferred solely from their frequency of participation.

This issue is particularly relevant to the Maple Magelang aerobic gymnastics community. Based on a preliminary survey involving a brief poll and initial observations conducted by the researcher, community members were found to participate regularly in weekly aerobic gymnastics sessions. However, observations of several movements revealed variations in participants' ability to control their trunks and maintain postural stability while performing certain movements. These preliminary findings cannot be used to conclude that community members have low core strength; rather, they indicate the need for specific measurements and targeted training interventions to examine this ability. Previous research by Muladi and Kushartanti (2011) demonstrated that core stability training can improve trunk strength and dynamic balance in athletes. Rahma (2023) also reported that core stability training improved balance and abdominal muscle strength in pencak silat athletes. Meanwhile, Maulana et al. (2023) examined core muscle strengthening and balance training in relation to trunk flexibility and leg strength among older women. Although these studies support the importance of core muscle strengthening, their participants and research variables differ from those of aerobic gymnastics community members. Therefore, further research is needed to specifically investigate training interventions designed to improve core strength in physically active, non-athlete populations.

One training method that can be used to develop core muscle function is Pilates. Pilates is an exercise method that emphasizes movement control, concentration, breathing, postural alignment, flexibility, and core muscle strengthening through structured and controlled movements (Lorenzo, 2011). These principles allow Pilates to target movement coordination and core muscle activation as part of physical fitness development. Geremia et al. (2025) reported that a 20-week Pilates training program improved core muscle strength, stability, and functional fitness in the population studied. Ko et al. (2024) also identified differences in core muscle activity according to Pilates experience, with experienced practitioners demonstrating greater core muscle activity than beginners. These findings provide a basis for considering Pilates as a method that may support the development of core muscle function through structured exercise and improved movement control. However, these findings should be interpreted in accordance with the characteristics of the participants, intervention duration, and outcome variables assessed.

Pilates has two commonly used forms of training: Pilates Mat and Pilates Reformer. Pilates Mat is performed on a mat, primarily using body weight as resistance, whereas Pilates Reformer uses specialized equipment with a spring-resistance system that allows variations in movement and adjustments to resistance according to training needs (Yılmaz et al., 2025). These differences result in distinct training approaches. Pilates Mat requires participants to control their body positions while performing movements using their own body weight, whereas Pilates Reformer enables resistance to be applied through the equipment's mechanical system. Both methods may provide different training stimuli to the core muscles. A study by Yılmaz et al. (2025), which compared Pilates Mat and Reformer training in soccer players, found that both methods could benefit physical performance, although their effects differed across several performance components. However, findings concerning the physical performance of athletes do not directly establish which method is more effective in improving core strength among physically active, non-athlete populations. Therefore, the two methods need to be compared while considering the characteristics of the population and the specific outcome variable targeted by the study.

Based on the review of previous research, core stability training and Pilates have been used to develop core muscle strength, balance, and postural control (Muladi & Kushartanti, 2011; Rahma, 2023; Geremia et al., 2025). Research on Pilates has also examined core muscle activity in relation to training experience and compared Pilates Mat and Reformer in terms of several physical performance components (Ko et al., 2024; Yılmaz et al., 2025). Nevertheless, based on the literature reviewed for this study, evidence directly comparing the effects of Pilates Mat and Pilates Reformer on core strength among aerobic gymnastics community members, as a physically active non-athlete population, remains limited. This research gap warrants investigation because regular aerobic activity does not necessarily indicate an individual's level of core strength, while differences in resistance mechanisms between Pilates Mat and Reformer may produce different training responses. Research involving the Maple Magelang aerobic gymnastics community is expected to provide empirical evidence regarding changes in core strength in response to these two training methods.

Based on the foregoing discussion, this study aims to analyze the effects of Pilates Mat training on core strength, analyze the effects of Pilates Reformer training on core strength, and compare changes in core strength between the two training groups among members of the Maple Magelang aerobic gymnastics community. The findings are expected to contribute to sports science literature concerning the application of Pilates as a core muscle-strengthening method and to provide a basis for instructors and coaches to select appropriate training methods for individuals who regularly participate in aerobic activities.

METHOD

This study employed a quantitative approach using a quasi-experimental method with a Two-Group Pretest–Posttest Design. The study involved 20 members of the Maple Magelang aerobic

gymnastics community who met the research criteria. Participants were selected using purposive sampling and subsequently assigned to two groups using the ordinal pairing technique based on their initial measurement results. Each group consisted of 10 participants: the Pilates Mat group and the Pilates Reformer group.

The study was conducted at One Time Pilates, Magelang, with 14 training sessions delivered at a frequency of three times per week. Each session lasted approximately 60 minutes and consisted of a warm-up, the main training session, and a cool-down. Core strength was measured before and after the intervention using a Back and Leg Dynamometer.

The data were analyzed descriptively to determine changes in the mean scores of each group. Subsequently, a Mixed Analysis of Variance (Mixed ANOVA) was performed at a significance level of 0.05 to analyze changes over measurement time and differences in changes between the Pilates Mat and Pilates Reformer groups.

RESULT

Research Data Description

Core Strength in the Pilates Mat Group

Core strength data for the Pilates Mat group were obtained using a Back and Leg Dynamometer before and after the Pilates Mat training intervention. The pretest measurements were used to determine participants' initial core strength, while the posttest measurements were used to assess core strength after the Pilates Mat training program.

Table 1.

Descriptive Statistics for Core Strength in the Pilates Mat Group

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
Pretest_Mat	10	27.5	65.5	46.000	11.0479
Posttest_Mat	10	55.5	120.0	88.050	19.6602
Valid N (listwise)	10				

Table 1, the mean core strength score in the Pilates Mat group at pretest was 46.00, with a standard deviation of 11.05. The minimum pretest score was 27.50, while the maximum was 65.50. Following the Pilates Mat training program, the mean core strength score at posttest increased to 88.05, with a standard deviation of 19.66. The minimum posttest score was 55.50, while the maximum was 120.00. Descriptively, the mean core strength score increased by 42.05 from pretest to posttest.

Core Strength in the Pilates Reformer Group

Core strength data for the Pilates Reformer group were obtained using a Back and Leg Dynamometer before and after the Pilates Reformer training intervention. The pretest measurements were used to determine participants' initial core strength, while the posttest measurements were used to assess core strength after the Pilates Reformer training program.

Table 2.

Descriptive Statistics for Core Strength in the Pilates Reformer Group

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
Pretest_Reformer	10	23.5	63.5	44.850	12.1862
Posttest_Reformer	10	50.5	78.0	67.150	10.3523
Valid N (listwise)	10				

Table 2, the mean core strength score in the Pilates Reformer group at pretest was 44.85, with a standard deviation of 12.19. The minimum pretest score was 23.50, while the maximum was 63.50. Following the Pilates Reformer training program, the mean core strength score at posttest increased to 67.15, with a standard deviation of 10.35. The minimum posttest score was 50.50, while the maximum was 78.00. Descriptively, the mean core strength score increased by 22.30 from pretest to posttest.

Tables 1 and 2, both groups demonstrated an increase in mean core strength from pretest to posttest. In the Pilates Mat group, the mean increased from 46.00 to 88.05, while in the Pilates Reformer group, it increased from 44.85 to 67.15. The mean change was 42.05 in the Pilates Mat group and 22.30 in the Pilates Reformer group. Thus, descriptively, the Pilates Mat group showed a greater increase in mean core strength than the Pilates Reformer group. This difference was subsequently examined using Mixed Analysis of Variance (Mixed ANOVA) to determine the significance of changes over measurement time and the interaction between measurement time and training type.

Data Analysis

Normality Test

The normality test was conducted to determine whether core strength data in each study group were normally distributed. The Shapiro–Wilk test was used. Data were considered normally distributed when the significance value was greater than 0.05 ($p > 0.05$). The analysis was performed using Statistical Package for the Social Sciences (SPSS) version 27 for Windows. The normality test results for pretest and posttest data in the Pilates Mat and Pilates Reformer groups are presented in Tables 3 and 4.

Table 3.
Normality Test Results for Pretest Core Strength Data

Group	Shapiro–Wilk	df	Sig.	Interpretation
Pilates Mat	0.974	10	0.924	Normal
Pilates Reformer	0.969	10	0.881	Normal

As shown in Table 3, the Shapiro–Wilk test yielded significance values of 0.924 for the Pilates Mat pretest data and 0.881 for the Pilates Reformer pretest data. Both values were greater than 0.05 ($p > 0.05$). Therefore, the pretest data for both groups were considered normally distributed.

Table 4.
Normality Test Results for Posttest Core Strength Data

Group	Shapiro–Wilk	df	Sig.	Interpretation
Pilates Mat	0.954	10	0.710	Normal
Pilates Reformer	0.893	10	0.183	Normal

As shown in table 4, the Shapiro–Wilk test yielded significance values of 0.710 for the Pilates Mat posttest data and 0.183 for the Pilates Reformer posttest data. Both values were greater than 0.05 ($p > 0.05$). Therefore, the posttest data for both groups were considered normally distributed.

Homogeneity Test

The homogeneity test was conducted to determine whether the variances in core strength data were homogeneous between the Pilates Mat and Pilates Reformer groups. Levene’s test was used. Variances were considered homogeneous when the significance value was greater than 0.05 ($p > 0.05$). The analysis was performed using SPSS version 27 for Windows. The homogeneity test results for the pretest and posttest data are presented in Tables 5 and 6.

Table 5.
Homogeneity Test Results for Pretest Core Strength Data

Data	Levene Statistic	df1	df2	Sig.	Interpretation
Pretest	0.032	1	18	0.860	Homogeneous

As shown in table 5, Levene’s test yielded a significance value of 0.860 for the pretest data. This value was greater than 0.05 ($p > 0.05$), indicating that the pretest variances in the Pilates Mat and Pilates Reformer groups were homogeneous.

Table 6.
Homogeneity Test Results for Posttest Core Strength Data

Data	Levene Statistic	df1	df2	Sig.	Interpretation
Posttest	1.895	1	18	0.186	Homogeneous

As shown in Table 6, Levene’s test yielded a significance value of 0.186 for the posttest data. This value was greater than 0.05 ($p > 0.05$), indicating that the posttest variances in the Pilates Mat and Pilates Reformer groups were homogeneous.

Based on the normality and homogeneity tests, the data met the preliminary assumptions for analysis. The pretest and posttest data in both groups were normally distributed, and the variances between groups were homogeneous. Therefore, the analysis proceeded using Mixed Analysis of Variance (Mixed ANOVA) to test the research hypotheses.

Hypothesis Testing

Tests of Within-Subjects Effects

The within-subjects effects analysis was used to examine changes in core strength over measurement time, from pretest to posttest, and to assess the interaction between measurement time and training group. The results are presented in Table 7.

Table 7.

Tests of Within-Subjects Effects

Source of Variation	F	Sig.	Partial Eta Squared
Time	85.091	<0.001	0.825
Time × Group	8.015	0.011	0.308

As shown in table 7, the measurement-time factor (Time) had an F value of 85.091 and a significance value of $p < 0.001$. This value was below 0.05 ($p < 0.05$), indicating a significant change in core strength between pretest and posttest.

The interaction between measurement time and training group (Time × Group) had an F value of 8.015 and a significance value of $p = 0.011$. This value was below 0.05 ($p < 0.05$), indicating a significant interaction between measurement time and training group in relation to core strength. This means that the change in core strength from pretest to posttest differed between the Pilates Mat and Pilates Reformer groups. The partial eta squared value was 0.825 for the Time factor and 0.308 for the Time × Group interaction. These values indicate the proportion of variation associated with each effect in the analytical model.

Tests of Between-Subjects Effects

The between-subjects effects analysis for the group factor (Group) was used to examine differences in core strength between the Pilates Mat and Pilates Reformer groups. The results are presented in Table 8.

Table 8.

Tests of Between-Subjects Effects

Source of Variation	F	Sig.	Partial Eta Squared
Group	4.667	0.044	0.206

As shown in table 8, the between-subjects effects analysis for the group factor (Group) yielded an F value of 4.667 and a significance value of $p = 0.044$. This value was below 0.05 ($p < 0.05$), indicating a difference in core strength between the Pilates Mat and Pilates Reformer groups. The partial eta squared value of 0.206 indicates the effect size associated with the group factor in the analytical model. This result should be interpreted alongside the Time × Group interaction in the Tests of Within-Subjects Effects. The interaction yielded $p = 0.011$ ($p < 0.05$), indicating that the change in core strength from pretest to posttest differed between the Pilates Mat and Pilates Reformer groups. The hypothesis testing using Mixed Analysis of Variance (Mixed ANOVA) indicated a significant change in core strength between pretest and posttest, a difference in core strength between the Pilates Mat and Pilates Reformer groups, and a significant interaction between measurement time and training group. These findings provide the basis for interpreting the results in relation to relevant theories and previous research.

DISCUSSION

Effects of Pilates Mat Training on Core Strength

The results showed that the mean core strength score in the Pilates Mat group increased from 46.00 at pretest to 88.05 at posttest, representing a mean change of 42.05. The Mixed Analysis of Variance (Mixed ANOVA) indicated a significant change over measurement time ($p < 0.001$). This

improvement may be associated with the characteristics of Pilates Mat, which emphasizes body control, postural alignment, movement coordination, and core muscle engagement. Regular training over 14 sessions provided repeated stimuli for the core muscles. Thus, the Pilates Mat group demonstrated an increase in mean core strength among the study participants.

Effects of Pilates Reformer Training on Core Strength

The Pilates Reformer group experienced an increase in mean core strength from 44.85 at pretest to 67.15 at posttest, representing a mean change of 22.30. The Mixed ANOVA showed a significant change over measurement time ($p < 0.001$). This change may be associated with the characteristics of Pilates Reformer, which uses a spring system to provide resistance during exercise. Participants are required to control their movements and maintain body position while performing the exercises. The training stimulus delivered over 14 sessions was associated with an increase in mean core strength in this group. Aerobic gymnastics is a highly demanding sport that requires a combination of explosive power, dynamic balance, and flawless execution of complex movements. At the center of this kinetic chain is the "core" or powerhouse, which transfers force between the upper and lower extremities. Recent research emphasizes that systematic core strength training is essential for improving the execution quality of high-difficulty elements in aerobic gymnastics (Hao, Wang, & Zhang, 2023). Furthermore, targeted core conditioning has been shown to directly enhance the technical performance and stability of gymnasts during routine elements (Ge, 2021). Because core stability acts as the foundation for movement efficiency and injury prevention (Bliven & Anderson, 2013), modern gymnastics communities are increasingly integrating specialized modalities, such as Pilates, into their conditioning programs.

The Pilates method, originally developed for rehabilitation purposes, has gained significant traction in athletic populations due to its focus on centering, controlled breathing, and deep muscle activation (Petruck et al., 2021). According to Kim and Lee (2017), the "centering" principle of Pilates facilitates the activation of local stabilizing muscles, thereby firmly establishing spinal stability. This neuromuscular control is a critical component of functional movement, enabling athletes to maintain proper alignment and utilize force effectively (Beardsley & Contreras, 2014; Zemková & Zapletalová, 2022). Regular participation in core stabilization programs, including Pilates, actively improves lower back endurance and dynamic balance in physical activities (Aggarwal, Kumar, & Kumar, 2010). When comparing training modalities, the aerobic gymnastics community often utilizes both Pilates Mat and Pilates Reformer training. Mat Pilates relies on gravity and the athlete's own body weight to provide resistance. Studies utilizing electromyography confirm that Mat Pilates significantly activates the deep core musculature, including the transversus abdominis and multifidus, which are vital for trunk stabilization (Marques et al., 2013; Tsartsapakis et al., 2023). Because it demands unassisted balance and proprioception, Mat Pilates serves as an accessible and highly effective method to build foundational core endurance and functional mobility in athletes (Šniurevičienė et al., 2022).

In contrast, Pilates Reformer training introduces external spring resistance and a moving carriage, allowing for sport-specific modifications. The Reformer provides variable resistance that can either assist a gymnast during neuromuscular re-education or challenge them with greater loads during dynamic movements (Lima et al., 2021). This external resistance allows gymnasts to build functional strength and core stability through a broader range of motion compared to Mat training alone (Hornsby & Johnston, 2020). Incorporating specialized equipment helps address the exact biomechanical demands and explosive force transfers needed during gymnastics routines, thereby optimizing overall athletic function (Clark et al., 2022).

Ultimately, both Mat and Reformer Pilates provide profound benefits for gymnasts. Twelve weeks of structured core training has been shown to yield significant improvements in core muscle performance and functional stability in gymnastics populations (Esteban-García et al., 2021).

Integrating these static and dynamic stabilization strategies optimizes physical conditioning and translates to superior technical precision on the floor (Wijaya et al., 2024). Therefore, combining both Mat and Reformer Pilates offers a comprehensive approach to developing the elite core strength required for competitive success in the aerobic gymnastics community.

Differences Between the Effects of Pilates Mat and Pilates Reformer on Core Strength

Descriptively, the mean increase in core strength was greater in the Pilates Mat group (42.05) than in the Pilates Reformer group (22.30). The Mixed ANOVA showed a significant interaction between measurement time and training group ($F = 8.015$; $p = 0.011$; partial eta squared = 0.308). This result indicates that changes in core strength from pretest to posttest differed significantly between the two groups. This difference may be related to the characteristics of the training methods: Pilates Mat uses body weight as resistance, whereas Pilates Reformer uses equipment with a spring-resistance system. Both methods showed an increase in mean core strength, but the Pilates Mat group demonstrated a greater descriptive improvement. These findings should be interpreted with consideration of the limited sample size of 20 participants and the quasi-experimental study design.

CONCLUSION

This study showed that mean core strength increased in both the Pilates Mat and Pilates Reformer groups after 14 training sessions. The mean increase was 42.05 in the Pilates Mat group and 22.30 in the Pilates Reformer group. The Mixed ANOVA showed a significant difference in changes between the two groups. Descriptively, the Pilates Mat group demonstrated a greater mean improvement among the members of the aerobic gymnastics community studied.

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